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Infant Visual Processing: Comparing Predictor Variables

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by

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VITA

The author, Stephanie Rychlak Stilson, is the daughter of Dr. Joseph Frank Rychlak and Mrs. Lenora Smith Rychlak. She was born May 16, 1961 in Pullman, Washington.

Her elementary education was obtained in the public schools of St. Louis, Missouri and Lafayette, Indiana. Secondary education was gained at McCutcheon High School in Lafayette, where she graduated in 1979.

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INTRODUCTION

The field of developmental psychology has had a strong tradition of interest in cognitive processes. Research has sought relationships between early and later cognitive functioning in an effort to determine whether human cognition can be understood in terms of stable and predictable unfolding patterns. It is difficult, however, to isolate infant behaviors that reflect rudimentary cognitive abilities since it involves the study of preverbal organisms equipped with seemingly limited intellectual capacities. Therefore, Fantz's (1958) introduction of a paradigm to measure infant visual recognition memory (presumed to tap rudimentary cognitive processing abilities) profoundly influenced the field of developmental psychology.

Performance assessed through infant visual recognition paradigms frequently has been correlated with standardized measures of cognitive outcome (i.e., the Bayley Scales, the Stanford Binet Intelligence Test, and the Wechsler Intelligence Scales), and significant correlations are presumed to indicate that these infant looking patterns reflect primitive aspects of cognitive processing not susceptible to radical developmental changes. In spite of this tradition, however, several questions remain regarding the analysis of infant looking behaviors. For example, what cognitive processes are being assessed by these visual paradigms? Cohen (1972, 1973) postulates that different looking patterns actually assess different aspects of attention within infant cognitive processing. He distinguishes between (1) the delay of the infant's first fixation and (2) the fixation duration (time spent looking at a stimulus) with the interpretation that they tap two separate processes -- namely "attention getting" and "attention holding," respectively.

Analyses of different aspects of looking behaviors may yield different results within the same infant observed longitudinally, suggesting that some looking patterns may be more resistant than others to developmental and/or environmental influences such as motivation for the task, fatigue, and the affective quality of target stimuli. If the researcher's intent is to use visual processing paradigms to isolate some continuous stream of cognitive ability, it behooves him or her to seek ways of analyzing those aspects of infant looking behaviors least altered by developmental and external influences. The results, presumably more stable than others, should provide more consistent predictive information than measures sensitive to the infant's developmental progress and environmental conditions.

In an effort to isolate the most stable and consistent method of analyzing infant visual processing, four different measures of looking behavior assessed through a visual paired comparison paradigm will be studied: (1) average delay to first fixation, (2) average time spent looking at a regular face stimulus, (3) average times spent looking at a scrambled face stimulus, and (4) average length of each look. The first three measures are common to studies of infant visual processing: the fourth measure is proposed as a logical extension of the others, postulated to be most likely to remain stable across time. Study I will determine which of the four measures is most stable across time by comparing scores obtained at 2-, 4-, and 6-months of age. Because it may be possible to have short-term instability within the four methods of analyzing infant looking behaviors and yet still have long-term predictability, a second hypothesis is considered. Study II will assess the comparative predictive ability of these four measures by correlating each to an outcome criterion (Wechsler Preschool and Primary Scale of Intelligence at 5 years). The assessment found to be most stable in Study I is hypothesized to be the most consistently predictive to the WPPSI in Study II.

While one cannot expect to isolate one single pattern of looking behavior reliably predicting performance in all areas of cognition, continued examination of relationships within longitudinal analyses may lead to an understanding of common underlying cognitive processes and their developmental trends. By targeting a way of analyzing infant visual processing that is stable throughout early infancy and minimally affected by external influences, developmental psychologists may gain a more valid assessment tool for measuring early cognitive abilities. More accurate measurements will permit earlier remedial interventions, where appropriate.

REVIEW OF RELATED LITERATURE

Visual Information Processing: There is growing agreement that infant cognitive measures are better predictors to later cognitive functioning when they rely less on motor and sensory skills and more on information processing skills (Bornstein and Sigman, 1986; Sternberg, 1985). Infant visual processing paradigms are used to assess information processing skills by observing the infants' performance on habituation tasks, responses to novel stimuli, and selections in paired comparison situations. **Habituation** usually is indexed by the amount or rate of decay in looking or by the cumulative amount of looking infants show to a repeated or a constant stimulus. Greater decrements, quicker decays, or relatively lesser amounts of cumulative looking to the repeated stimulus in conjunction with increased looking to a novel stimulus generally are interpreted as more efficient styles of processing. **Responses to novel stimuli** are indexed by the relative amounts of looking infants pay to novel over familiar stimuli after a familiarization period. Relatively greater amounts of looking at novel stimuli, or reciprocally lesser amounts of looking at familiar stimuli, generally are interpreted as more efficient processing. **Paired comparison tasks** assess the relative amounts of looking infants pay to one stimulus over another when presented in a side-by-side display.

While their use in developmental psychology has been vast, visual processing paradigms have been criticized on several grounds. The type of stimuli selected for these paradigms varies widely. Investigators have compared reactions to facial stimuli (photographs of faces, line drawings, paper mache masks, etc.) as well as to radically different stimuli such as checkerboards and bulls' eyes. Unfortunately, stimuli often differ in overall luminance and contour density, both of which are known to influence infants' fixation time (Karmel & Maisel, 1975; Hershenson, 1964).

These paradigms also are faulted for their lack of psychometric soundness as reflected in the relatively low internal consistencies reported (Colombo, 1987; Fagen, 1984; Mundy, Siebert, Hogan, & Fagen, 1983; Rose, Feldman, & Wallace, 1988). Without internal stability, it is unclear whether only the individual's cognitive ability is being assessed. A particular set of data, therefore, may reflect a unique testing situation rather than, or in addition to, an individual's stable underlying cognitive ability. For these reasons, further research is needed to measure internal stability and consistency within the visual processing paradigms (Bornstein & Sigman, 1986).

Interpretations of findings from visual processing paradigms often are complicated because of the many different ways to analyze an infant's looking behavior. For example, length of visual fixation probably is the most frequently used measure in paired comparison paradigms (Caron & Caron, 1969; Sigman, Cohen, Beckwith, & Parmelee, 1985; Rose, Feldman, & Wallace, 1988); however, researchers also study the delay to the first fixation, the percentage of time spent looking at one stimulus over another, and the total number of looks made to a specific stimulus. Visual processing paradigms yield numerous ways of analyzing an infant's looking behavior, creating problems for data analyses, interpretation and generalization.

Moreoever, these different methods of analyzing infant looking behavior may actually assess different, independent aspects of the attentional process. For example, Cohen (1972, 1973) postulates that infant visual attention may not consist of a unitary process but may consist of multiple processing phases. Infant performance on a visual paired comparison task is a function of both "attention-getting" and "attention-holding" processes. Additionally, he suggests that these processes are sensitive to different stimulus parameters: attention-getting being sensitive to movement, brightness, size and distance; attention-holding to texture, contour, orientation and pattern. The possibility that infant visual behaviors tap individual differences within subjects' early attentional patterns has been a consistent focus in infancy research with others extending Cohen's theorizing. Ruff (1986), for example, distinguishes between two aspects of attention -- time to activate attention and time to encode information. Casey & Richards (1988) also studied conditions which correspond to two types of visual attention phases -- sustained attention and attention termination.

Individual Differences: One of the more interesting (yet least researched) areas of infant visual processing suggests that although habituation patterns for groups of subjects tend to be linear or an exponential decreasing function of the number of trials, there is no guarantee that individual infants display curves congruent with this group trend (Bornstein, 1985; McCall, 1979). In fact, there appear to be three clearly differentiated patterns. McCall and Kagan (1970) identified "rapid habituators," "slow habituators," and an "idiosyncratic" type, and Bornstein and Benasich (1983) identified parallel "exponential decreasing," "increase-decreasing," and "fluctuating" patterns of habituators. Therefore, it is possible that performance on these infant looking tasks reflect not only different types of processing (attentional patterns) but also early individual cognitive styles or strategies.

Ruff (1975) and Harris (1973) also predicted that individual cognitive styles could be studied through visual processing paradigms. Infants' fixation shifts between two paired stimuli were hypothesized to reflect the individualized patterns of active comparison between simultaneously presented stimuli. Ruff (1975) explored both the conditions affecting the number of shifts and the effects of visual shifts on other infant visual responses. She counted the number of shifts per trial the infants made between the two paired stimuli and then, suspecting a possible relationship between looking time and number of shifts in each trial, she divided the number of shifts by the looking time, yielding a "shifts-per-second" measure. The results indicated that infants shifted more when the similarity within the pair was increased. Her findings, unique to the infancy literature, prompted her to conclude that the "...number of shifts is a measure worth investigating in other infant perceptual studies" (p. 864). Despite Ruff's suggestion, little has been done with this particular visual processing measure. Indeed, to this researcher's knowledge, no study has attempted to demonstrate any relationship between visual shifts per second and later measures of cognitive outcome; however, Colombo, Mitchell, & Horowitz (1988) recently referenced Ruff's work wondering whether individual differences in infants' shifting might reflect differential "strategies" for dealing with stimulus comparisons.

In summary, developmental researchers analyze infant looking behaviors using visual processing paradigms for several reasons: (1) to tap potentially different information processing functions such as attention getting and attention holding, and (2) to distinguish individual differences in visual processing styles or strategies. A (3) third purpose, indirectly encompassing the first two, is the desire to predict developmental outcome. Specifically, measures from visual processing paradigms often are used to predict later cognitive performance.

Predicting Later Cognitive Performance: A number of studies have found relationships between infant visual processing behaviors and subsequent intellectual capacities. For example, Fantz & Nevis (1967) compared home-reared offspring of highly intelligent parents with institution-reared offspring of women of average intelligence, and Miranda & Fantz (1974) compared Down's Syndrome with normal infants. In both studies, infant groups expected to be more intelligent later in life also were superior in visual recognition tasks during infancy. Fagan & McGrath (1981) found significant correlations between infant recognition memory scores obtained from four to seven month old infants and later vocabulary tests of intelligence at four (r=.37) and seven (r=.57) years, respectively. They administered the Peabody Picture Vocabulary Test (Form B), the picture vocabulary portion of the Stanford-Binet Intelligence Test and the vocabulary subtest of the WPPSI. Indeed, Fagan's Case Western Reserve group has found significant correlations between visual processing performance and later measures of verbal intelligence in numerous different samples (Sigman, Cohen, Beckwith & Parmelee, 1986). Therefore, there appears to be substantial evidence that looking behaviors from early infancy reveal meaningful cognitive individual differences (Caron, Caron, & Glass, 1983; Lewis & Brooks-Gunn, 1981; Rose & Walters, 1985).

What might these robust correlational findings indicate about the stability (or instability) of cognitive development? Unfortunately, they shed little light on the nature of the cognitive processes measured by assessments such as fixation time, delay to first fixation, and number of looks. At best, significant correlations between infant visual processing and later cognitive performance suggest that there is an underlying continuous process. It is thought that this particular process is "tapped" by both the predictor and criterion measures selected in these correlational studies; however, the nature of this process is unknown. Some might hypothesize, for example, that what is "continuous" between early and later measures is <u>not</u> cognitive or intellectual ability, but instead is motivational or temperamental (Bornstein & Sigman, 1986). A recent call was made for research exploring the nature of factors assessed by visual processing measures and to identify which "...processes are continuous, the bases for the continuity, and the factors that maintain or disrupt the continuity from infancy to childhood" (Sigman, Cohen, Beckwith, & Parmelee, 1986, p. 791).

One way to explore the nature of infant visual processing is to compare the various ways of assessing infant looking patterns over a short period of development to evaluate their stability and consistency. Specifically, if infant visual processing measures such as fixation time, delay to first fixation, and number of looks at a stimulus tap the same stable cognitive process, then, relative to their peers, infants should perform similarly when repeatedly assessed by these various measures over a short period of time. If, however, certain visual assessments are substantially influenced by factors other than the infant's stable cognitive process (e.g., environmental factors), then short term stability would not be expected. Study I will analyze this premise by comparing the short-term stability of four separate ways of analyzing visual processing (average delay to first fixation, average time spent looking at a regular face stimulus, average time spent looking at a scrambled face stimulus, and average length of each look).

Of all the methods of assessing infant looking behaviors, the "average length of each look" is hypothesized to reflect a more stable (unlearned) aspect of visual processing. Following from the implications drawn by Ruff (1975), Harris (1973), and Columbo, et al. (1988), it is postulated that the "average length of each look" aptly will capture the "back and forth" (i.e., active) shifting of the infant's visual processing. Further, it is anticipated that the individual differences surrounding this active processing will be largely characteristic of each infant's basic cognitive strategies and hence less influenced by environmental changes. Reciprocally, behavior as captured by the method of assessment "average time spent looking" at a particular stimulus is postulated to reflect a more stimulus-bound (i.e, learned) aspect of the infant's visual processing experience. Performance assessed via this analysis, then, is expected to reflect less the infant's basic cognitive processing and more the meaning attributed to the stimulus by the infant. Time spent looking at each stimulus type therefore is hypothesized to vary across the 2 to 6-months span of time because the meaning given to the face-like stimulus is presumed to change for the infant during this developmental period. Delay to first fixation is believed to capture the infant's initial "attention getting" behavior (Cohen, 1972, 1973), and therefore is expected to be largely influenced by the infant's state at the time of the experimental task. No stability across the 2-, 4-, and 6-months evaluations is expected. These are the speculations tested in the following studies.

> <u>Hypothesis I (Study 1)</u>: The method of analyzing looking behavior within a visual paired comparison paradigm that assesses the infant's "average length of each look" will show more stability across 2-, 4-, and 6-months assessments than will three other frequently used methods of assessing looking patterns (i.e., "average delay of first fixation," "average time spent looking at a regular face stimulus," and "average time spent looking at a scrambled face stimulus").

Given the substantial empirical support for the predictive ability of visual processing paradigms, a second study questions which of these four ways of assessing infant looking behaviors best taps what is presumed to be "continuous" from infancy to childhood. Just as it is hypothesized that these four assessments will differ in the short run because they do not equally tap the infant's continuous, stable cognitive process but rather are influenced unequally by developmental and/or environmental factors, it is hypothesized that the four assessments will yield different predictive patterns when correlated with five year WPPSI scores. Again, since the average length of each look is believed to be the least influenced by developmental and/or environmental factors, it is hypothesized to be a more consistently stable predictor of later outcome than the other three assessments. Study II tests the following hypothesis.

> Hypothesis II (Study 2): The method of analyzing looking behavior within a visual paired comparison paradigm that assesses the infant's "average length of each look" will correlate to a later measure of cognitive outcome (WPPSI) more consistently than will the three measures "average delay of first fixation," "average time spent looking at a regular face stimulus," and "average time spent looking at a scrambled face stimulus."

METHOD

Subjects: All infants were first-born children of upper-middle socio-economic status, intact families. No infants with known physical or central nervous system anomalies were included. Infants were selected from an ongoing longitudinal project at Evanston Hospital, Evanston, Illinois. This study is following the outcome of infants born with varying perinatal conditions: preterm (37 weeks or less gestational age) and fullterms in intensive care (high risk group); fullterms with sick mothers and a control group of healthy fullterms (low risk group). See Holmes, Reich, Gyurke (1989) for a more complete description of these groups. Infants' gestational age at birth was determined by the Dubowitz assessment and by mothers' reports of last menstrual period. All data collected during this extensive longitudinal study were analyzed using corrected ages for infants of short gestational age. The decision to use ages corrected for gestation at birth was made to minimize differences in performance on age-standardized tests (Holmes, Reich, & Rieff, 1988); however, the effect of correcting for gestational age at birth is thought to be minimal by the time the children are 4 or 5 years old (Siegel, 1983).

All subjects having complete data for all of the measures used in these analyses (i.e., visual paired comparison task scores at 2-, 4-, and 6-months of age and the five-year WPPSI score) were selected from this larger pool of subjects. A total of 19 infants comprise the study sample (birth weight: mean=2708 grams, s.d.=780.9; gestational age: mean=37 weeks, s.d.=3.4). Of these 19 infants, all were within normal range on standard developmental tests at the five-year assessment. At the time of birth, 14 of these children were members of the longitudinal high-risk group (9 preterm and 5 sick fullterm), and 5 were from the longitudinal low-risk group (3 fullterm with sick mothers and 2 healthy fullterm). The same subject pool is used in both Study I and Study II (Table 1).

Procedure: Data were collected from the following four assessments: (1) Visual paired comparison paradigm at 2-months; (2) Visual paired comparison paradigm at 4-months; (3) Visual paired comparison paradigm at 6-months; and (4) Wechsler Preschool and Primary Scale of Intelligence (WPSSI), at the end of kindergarten. Infant looking patterns were observed in a visual paired comparison task at three different times: 2-months, 4-months, and 6-months of age. Procedures and stimuli similar to those used by Fagan (1979) and Fantz, Fagan & Miranda (1975) were used. Infants sat on their mother's lap in a chair located 6 feet from the projection screen.

Table 1
Demographic Characteristics of Study Sample

Measures	Sample (n)	Minimum/ Maximum	Mean	Standard Deviation
Birthweight (gm)	19	1200/4338	2708	780.9
Gestational Age (wks)	19	29/41	37	3.4
Days in Hospital	19	2/78	17	16.8
Obstetric Complications Scales Score*	19	57/160	98	27.8
Postnatal Complications Scale Score*	19	67/160	104	39.3
Maternal Age in Years	18	23/35	29	2.8
Maternal Years of Education	18	12/19	17	1.7
Paternal Years of Education	17	12/20	17	2.1

*High scores on the Obstetric Complications Scales and Postnatal Complications Scales indicate fewer medical complications (Littman & Parmelee, Note 1).

Infants were presented 35mm slides of black and white schematic representations of one scrambled face and one regular face, side-by-side, for ten seconds (Kagan, 1967). Each infant participated in two 10-second trials. The two stimuli then were switched for Trial 2 to counterbalance right and left positioning and thereby eliminate a potential order-preference confound. An array of flashing lights in the middle of the screen was used to direct the infant's attention to the center of the blank screen prior to each of the two trials. Each trial began as soon as the infant focused on this array. The observer, blind to stimuli presentation and birth condition, unobtrusively watched through a hole in the screen and recorded the infants' looking patterns into a tape recorder indicating, for example, which side of the screen the infant was looking at, when the looking behavior shifted, etc. The following four summaries of looking behavior later were calculated from the tape recorded information: (1) the average delay to first fixation averaged across both trials; (2) the time spent looking at the regular face averaged across both trials; (3) the time spent looking at the scrambled face averaged across both trials; and (4) the average length of each look (total looking time divided by total number of looks) averaged across both trials and both types of stimuli.

The Wechsler Preschool and Primary Scale of Intelligence (WPPSI) was administered to study participants during the last two months of kindergarten by a trained examiner blind to the child's perinatal history. The WPPSI is a standardized intelligence test used with 4 to 6.5 year olds. By providing separate verbal and performance IQ scores, it is thought to be more sensitive to subtle learning disabilities than many other IQ tests (Wechsler, 1967). The test was scored according to standard instructions, yielding both the performance IQ and verbal IQ scores.

RESULTS

Study One/Hypothesis I: The method of analyzing looking behavior within a visual paired comparison paradigm assessing the infant's "average length of each look" will show more stability across 2-, 4-, and 6-months assessments than will three other frequently used methods of assessing looking patterns (i.e., "average delay of first fixation," "average time spent looking at a regular face stimulus," and "average time spent looking at a scrambled face stimulus").

To test this hypothesis, three Pearson Product Moment Correlations were calculated using the infants' 2-, 4-, and 6-months visual processing data. Correlation coefficients were derived between the infants' visual performance at 2-and 4-months, 4-and 6-months, and 2-and 6-months. These three correlations were computed for each of the four methods of analyzing infant looking behaviors: (1) average length of each look to the stimuli, across both trials (ALL); (2) average delay of first fixation, across both trials (AD1F); (3) average time spent looking at a regular face stimulus, across both trials (ATLRF); and (4) average time spent looking at a scrambled face stimulus, across both trials (ATLSF).

Results, summarized in Tables 2 and 3, do not support Hypothesis I (Study 1). Analysis of infant

Table 2
<u>Pearson Product Moment Correlations across time on four different ways of analyzing infant looking patterns</u>

	2mo to 4mo r (p)	4mo to 6mo r (p)	2mo to 6mo r (p)
Average Length of Each Look	.4008 (.045)	-.0293 (n.s.)	-.3725 (.058)
Average Delay to First Fixation	.1201 (n.s.)	.5500 (.007)	.3404 (n.s.)
Average Time Spent Looking at a Regular Face	.1253 (n.s.)	-.2313 (n.s.)	-.2060 (n.s.)
Average Time Spent Looking at a Scrambled Face	.4990 (.015)	.4522 (.026)	.6330 (.002)

Table 3
Descriptive Information across time on four different ways of analyzing infant looking patterns: Means and Standard Deviations

		2 months	4 months	6 months
Average Length of Each Look	(x)	2.844	1.406	1.448
	(sd)	2.089	0.623	0.892
Average Delay to First Fixation	(x)	4.021	3.253	2.774
	(sd)	2.329	1.995	1.194
Average Time Spent Looking at a Regular Face	(x)	2.208	2.282	2.134
	(sd)	2.034	1.135	1.225
Average Time Spent Looking at a Scrambled Face	(x)	1.963	1.692	1.829
	(sd)	1.738	1.008	1.417

looking behavior summarized by the "average length of each look" was not the most stable across 2-, 4-, and 6-months assessment as is reflected by the sign change in the correlation coefficients corresponding to each time period (2 to 4-months: r = .4008, p = .045; 4 to 6-months: r = -.0293, p = n.s.; 2 to 6-months: r = -.3725, p = .058). In fact, Table 2 suggests that the analysis of infant looking behavior which summarized the infant's "time spent looking at a scrambled face" appears to be the most consistently stable (2 to 4-months: r = .4990, p = .015; 4 to 6-months: r = .4522, p = .026; 2 to 6-months: r = .6330, p = .002).

Because of the significant findings obtained with the analysis method "time spent looking at a scrambled face" but not "time spent looking at a regular face" (Table 2), further analyses were conducted to determine if the type of stimulus (i.e., scrambled versus regular face) was a factor in the findings represented by the "average length of each look." Specifically, correlational analyses tested the stability of the average length of each look to a <u>regular</u> face and the average length of each look to a <u>scrambled</u> face. No significant findings emerged, indicating that the stimulus type (i.e., scrambled vs. regular face) does not seem to influence results when the average length of each look is used in the analysis (Table 4).

Table 4

Pearson Product Moment Correlations between performance on six different analyses of early infant visual processing assessed across three different developmental periods.

Average Length of Each Look (regardless of stimulus)

2 ==> 4 months	r= .4008	p= .045
4 ==> 6 months	r= -.0293	p= n.s.
2 ==> 6 months	r= -.3725	p= .058

Average Length of Each Look to a Scrambled Face

2 ==> 4 months	r= .2457	p= n.s.
4 ==> 6 months	r= .2280	p= n.s.
2 ==> 6 months	r= .1485	p= n.s.

Average Length of Each Look to A Regular Face

2 ==> 4 months	r= .2753	p= n.s.
4 ==> 6 months	r= -.2429	p= n.s.
2 ==> 6 months	r= -.1882	p= n.s.

Time Spent Looking (regardless of stimulus)

2 ==> 4 months	r= .2184	p= n.s.
4 ==> 6 months	r= .1679	p= n.s.
2 ==> 6 months	r= .0246	p= n.s.

Time Spent Looking at a Regular Face

2 ==> 4 months	r= .1253	p= n.s.
4 ==> 6 months	r= -.2313	p= n.s.
2 ==> 6 months	r= -.2060	p= n.s.

Time Spent Looking at a Scrambled Face

2 ==> 4 months	r= .4990	p= .015
4 ==> 6 months	r= .4522	p= .026
2 ==> 6 months	r= .6330	p= .002

Study Two/Hypothesis II: The method of analyzing looking behavior within a visual paired comparison paradigm which assesses the infant's "average length of each look" will correlate to a later measure of cognitive outcome (WPPSI) more consistently than will the three measures "average delay of first fixation," "average time spent looking at a regular face stimulus," and "average time spent looking at a scrambled face stimulus."

A Pearson Product Moment correlation was computed between the early observations (i.e., visual paired comparison analyses: ALL, AD1F, ATLRF, and ATLSF) and later outcome (i.e., WPPSI score). This relationship was calculated at each age (i.e., 2-, 4-, and 6-months) to produce a total of twelve *r* values. Separate analyses tested relationships between early performance and the WPPSI verbal and performance sub-scores (WPPSI verbal: mean=117.37, s.d.=7.3; WPPSI performance: mean=116.63, s.d.=8.4). Results, summarized in Table 5, do not support Hypothesis II (Study 2). Analysis of infant looking behavior summarized by the "average length of each look" was not the most consistently predictive to the criterion measure when correlated at 2-, 4-, and 6-months of age. This is perhaps best reflected by the sign reversal of the correlation coefficients when each time period was correlated with the WPPSI performance sub-score (2-month to

Table 5

<u>Pearson Product Moment Correlations between performance on four different analyses of early infant visual processing and later cognitive ability</u>

		WPPSI Performance r (p)	WPPSI Verbal r (p)
Average Length of Each Look	2mo:	.4081 (.041)	.0169 (n.s.)
	4mo:	.1681 (n.s.)	.0893 (n.s.)
	6mo:	-.4438 (.029)	.1363 (n.s.)
Average Delay First Fixation	2mo:	.1023 (n.s.)	.3078 To (n.s.)
	4mo:	-.0187 (n.s.)	.1501 (n.s.)
	6mo:	.3064 (n.s.)	.4756 (.020)
Average Time Spent Looking at a Regular Face	2mo:	.4019 (.044)	.1228 (n.s.)
	4mo:	.1629 (n.s.)	.1323 (n.s.)
	6mo:	-.0897 (n.s.)	.1826 (n.s.)
Average Time Spent Looking at a Scrambled Face	2mo:	-.3990 (.045)	-.0786 (n.s.)
	4mo:	-.0046 (n.s.)	-.0513 (n.s.)
	6mo:	-.5114 (.013)	-.4671 (.022)

WPPSI: *r* = .4081, *p* = .041; 4-months to WPPSI: *r* = .1681, *p* = n.s.; 6-months: *r* = -.4438, *p* = .029). Table 5 suggests that the analysis of infant looking behavior summarized by the infant's "time spent looking at a scrambled face" stimulus appears to be the most consistently predictive to the WPPSI performance sub-score (2-months: *r*= -.3990, *p* = .045; 4-months: *r* = -.0046, *p* = n.s.; 6-months: *r* = -.5114, *p* = .013). Again, additional analyses revealed no significant findings when the method of analysis "average length of each look" was separated and tested by stimulus types (i.e., regular and scrambled faces).

None of the methods of analyzing infant looking behavior successfully predicted verbal outcome until the 6-month visual preference performance. Both the six months "delay to the first fixation" (*r* = .4756, *p* = .020) and the "time spent looking at the scrambled face" (*r* = -.4671, *p* = .022) performances correlated significantly with the WPPSI verbal sub-score.

The two infant looking measures found in Study II to be the most consistently predictive to five-year WPSSI performance (i.e., time spent looking at a scrambled face and average length of each look) were entered into step-wise multiple regressions using three different criteria: (1) WPPSI performance sub-score, (2) WPPSI verbal sub-score, and (3) the difference between the two WPPSI sub-scores. These 2- and 4-months infant visual paired-comparison data were not able to account for a significant portion of the variance for any of the three criteria. However, at 6-months, time spent looking at a scrambled face entered negatively into the equation when both the performance sub-score [Multiple $R2$=.51142, $F(1,17)$=6.0211, p=.0252] and the verbal sub-score [Multiple $R2$=.46709, $F(1,17)$=4.74397, p=.0438] were the criterion measures. Interestingly, at 6-months, average length of each look entered into the equation when the criterion was the difference between the two sub-scores [Multiple $R2$=.52305, $F(1,17)$=6.40262, p=.0216], and this relationship also was negative.

DISCUSSION

The infants in this study constitute a "moderate" risk sample in that a large percentage (73%) of the infants were either preterm or fullterm infants requiring intensive hospital care. As noted earlier, these particular 19 infants were selected from the larger sample as only they had the complete data necessary for these analyses. It was perhaps an artifact of this selection procedure that a moderate risk sample resulted. By the three-year assessment, all infants in this study were within normal range on standard developmental tests, however.

Since the infants studied are characterized by a high degree of subject variability, it is possible that differences were detected despite the relatively limited sample size. Therefore, the significant findings reflected across the various correlational tests may be due, in part, to the fact that an atypical sample was used.

The method of analyzing infant looking behavior characterized by the "average length of each look" was hypothesized to reflect a more continuous aspect of the visual cognitive processing than, for example, the "average time spent looking" at a particular stimulus. Following from the implications drawn by Ruff (1975), Harris (1973), and Columbo, et al. (1988), it was postulated that the "average length of each look" would aptly capture the "back and forth" (i.e., active) shifting of the infant's visual processing. It further was anticipated that the individual differences surrounding this active processing would be largely characteristic of each infant's basic cognitive strategies and hence less influenced by developmental and environmental changes. Reciprocally, behavior as captured by the measure "average time spent looking" at a particular stimulus was postulated to reflect a less continuous aspect of the infant's visual processing experience, namely the stimulus' meaning or "captivating" influences. This measure, then, was hypothesized to vary across the 2 to 6-months span of time because the meaning attributed to the face-like stimulus was presumed to change during that developmental period. From the analyses peformed here, these hypotheses were not confirmed; however, it is possible that the brief ten-second trials did not allow enough time for individual differences in "shifts" or back and forth behavior to be demonstrated. To address this issue, future research should consider lengthening the duration of each trial.

The hypotheses guiding these two studies assumed that meaningful cognitive individual differences could be detected through analyses of infant looking behaviors. Further, it was speculated that certain measures of infant looking patterns (i.e., average length of each look) would more efficiently reflect the infants' stable cognitive styles or strategies than others (i.e, time spent looking at stimuli and delay to first fixation). While the original hypotheses were not confirmed, interesting patterns emerged that merit attention.

The time infants spent looking at a scrambled face (i.e., unfamiliar, abstract face) stimulus did not change across the brief developmental period examined in Study I. Highly significant correlations were found between performance at all developmental periods (i.e., from 2 to 4 months, 4 to 6 months, and 2 to 6 months). One might suggest, therefore, that when confronted with unrecognizable stimuli, infants' looking behaviors, relative to their peers, seem to stay the same through (at least) the first 6 months of life. Such consistency, however, was not discovered when a regular face served as the target stimulus. No significant correlations emerged for the various developmental periods analyzed. Thus, when confronted with recognizable or familiar stimuli, infants' relative ranks in terms of total looking times do change during this particular developmental period (2 to 6 months). The measure "time spent looking at a stimulus" appears to be linked (or related) to the particular stimulus type, at least for this sample population.

The finding that the measure "time spent looking at a stimulus" appears to be related to the stimulus type prompted post hoc analyses of the "average length of each look" measure. Specifically, correlational analyses were conducted with the 2-, 4-, and 6-month assessments, and the stimulus type (i.e., regular vs. scrambled face) was considered within these analyses. When the "average length of each look to a regular face" was compared to the "average length of each look to a scrambled face" across the developmental periods, no differences emerged. In fact, there was no stability found across any of the ages studied (Table 5). In summary, the measure "average length of each look" does not seem to be as strongly linked to the stimulus type as does "time spent looking at a stimulus." This is important because it suggests that the two measures are <u>not</u> measuring the same process. There is something about the stimulus type (the meaning attributed to the regular and/or scrambled faces) which influences the infants visual patterns when looking behaviors are measured by "time spent looking." On the contrary, when looking behaviors are measured by "average length of each look," the stimulus type appears to be irrelevant.

Precisely "what" each measure <u>is</u> assessing remains ripe for theoretical debate and empirical testing. If one hypothesizes that there exists a continuous "stream" of cognitive ability that, if found, could be assessed, then the measure "time spent looking" may tap aspects of development that disrupt that continuity. For example, Kagan (1967) postulates that an infant's performance on a visual task that uses facial stimuli results from a process of schema formation. As the child's "face schema" changes, so does his or her performance on visual preference tasks involving face-like stimuli. In the early months, infants prefer to attend to regular (i.e, normal) renderings of face stimuli because they are optimally discrepant from their relatively immature internal face schemata. As infants develop, however, their face schemata are expanded and they can "tolerate" greater variations from these internal representations; therefore, they begin to attend to scrambled or "less regular" faces. Thus, for Kagan, performance on preference tasks involving face stimuli is due, in part, to the infants' experiences with facial stimuli, a position supported by subsequent research (see Maurer, 1985 for review).

Perhaps this study captured a portion of this process of "face schema" development. Specifically, infants' responses to the regular face stimuli were not "stable" and consistent over the 2 to 6 months period. The lack of stability may reflect the developing individual differences of the infants in "preferring" a regular face. Looking responses to the scrambled face, however, were very consistent and stable during this time period. Facial schemata of the 2-, 4-, and 6-months old infants may not be advanced or developed enough to "tolerate" such a discrepant representation; therefore, the infants performed similarly when exposed to scrambled (unrecognizable) faces. If the longitudinal design had permitted evaluation of 8-, 10-, and 12-months old infants, a less stable pattern of looking responses to the scrambled face might have been discovered.

On the other hand, the measure "average length of each look" (found in this study to be minimally influenced by the stimulus type) may tap what is presumed to be "continuous" in the infant's approach on a cognitive task such as the visual-paired comparison paradigm. Further, this continuous process may be more innately determined and less influenced by experience than is the process tapped by "time spent looking." Perhaps the average length of each look is an indication of the infant's "cognitive style" or the strategy he or she employs. Again, this style would presumably be an aspect of the child's make-up -- an innate way of approaching a task such as the one given in this study. Granted, virtually nothing in human behavior is uninfluenced by development, but the stability found in performance when looking behaviors were measured by the average length of each look suggests that this particular method of assessing visual behavior is less influenced by experience (or learning) than were the other methods. Issues of temperament, intrinsic motivation (Hunt, 1970), self control or regulation, and general intelligence may be a few of the components that comprise an individual's "cognitive style."

Further evidence for the interpretation that the two ways of studying infant looking patterns may be tapping two separate aspects of cognition (one developmentally based and the other innately or stylistically based) was provided by Study II. It is important to point out that, in general, all of the ways of assessing looking behavior were more predictive of WPPSI performance intelligence quotient (IQ) scores than they were of verbal IQ scores. A high correlation might be expected given the visual-spatial emphasis of the infant visual processing task and the visual-motor skills assessed by the performance section of the WPPSI. However, some research has linked poor visual-motor skills with deficient performance in learning disability children (Bjerre & Hansen, 1976; Hunt, Tooley, & Harvin, 1982; Cohen, 1986). Many of these children score within normal range on a standardized test such as the WPPSI when the overall score is assessed (i.e., both performance and verbal); however, when the scores are viewed separately, large differences are discovered between the two scales. These difference scores are hypothesized to indicate potential learning disabilities (Bloom, Topinka, Goulet, Reese, & Podruch, 1986), and some learning disabilities are presumed to result from deficits in self control (Kopp, 1982; Vaughn, Kopp, & Krakow, 1984) and/or attention (Kopp, 1987; Jones, 1980). Since these are two of the components hypothesized to be associated with whatever process was being tapped by the "average length of each look," post hoc analyses were performed on the data of Study II.

Time spent looking at a regular face, time spent looking at a scrambled face, and average length of each look were entered into step-wise multiple regressions using three different criteria: (1) WPPSI performance IQ, (2) WPPSI verbal IQ, and (3) the difference between the two WPPSI IQ. Time spent looking at a regular face, however, accounted for no additional variance and therefore was dropped from further analyses. Only the 6-month visual processing data entered into the multiple regressions. Time spent looking at a scrambled face entered into the equation when both performance and verbal IQ scores were the criterion measures; however, average length of each look entered into the equation when the criterion was the difference between the two scales scores. Again, this supports the earlier contention that the two visual measures may well be tapping different aspects of the infant cognitive process. More importantly, however, it suggests that the average length of each look is a better predictor of WPPSI difference scores -- scores postulated to reflect the sorts of cognitive deficits related to learning disabilities.

A final comment is in order regarding the type of analyses used in this study. Developmental psychologists frequently form their research questions in terms of change and continuity across time. On occasion, the questions asked highlight the limitations of the available statistical analyses. Correlational analyses performed on longitudinal designs have been criticized when used as indicators of stability (or lack thereof) in developmental research. Rutter (1987), for example, reminds researchers that correlations are not measures of the strength of association despite their often being interpreted as such; rather, they are indexes of the proportion of population explained. Similarly, correlations rely on consistency of association <u>across the range</u>, rather than on an exact replica of performance.

These are some of the issues researchers must consider when their analyses are predominantly correlational; however, it should be stressed that in this study, it is not the mere presence of significant correlations that is highlighted. Rather, it is the difference in the short-term and long-term stability detected between the various visual processing measures that is of interest. When the correlation coefficients in this study were analyzed, dramatic differences were found with respect to the various measures of infant looking behavior. The fact that there is a strong correlation between the 2-month and 4-month visual performance as measured by the average time spent looking at a scrambled face is not of major importance in this particular study. What is important is that the two measures "time spent looking" and "length of each look" appear to yield different information about the processing of visual stimuli in developing infants.

In summary, this research, conceived and executed as exploratory, indicates that developmental psychologists have in the paired comparison paradigm a tool which seems to effectively tap different aspects of growing infants' cognitive visual processing. These findings, resulting in part from post hoc analyses, must be replicated, however. Follow-up research must verify that infants exposed to numerous target stimuli during the 2- to 6-months period will show consistent (stable) performance when assessed using "average length of each look" and less consistent (unstable) performance when assessed using "time spent looking." In other words, convergent validity is needed to verify that the type of stimulus used _is_ a factor in the cognitive process which is tapped by the time spent looking measure, but _is not_ in the process tapped by the length of each look measure. If such findings are replicated, research then can seek to break down the factors related to the hypothesized different processes (e.g., motivation, control, understanding of target stimuli, etc.). Clearly, much remains to be learned about what happens to humans as a result of "experience" and hence much uncertainty remains about the processes involved in developmental continuity and discontinuity. However, exploratory research such as this attempts to contribute to the field's understanding of cognitive development by studying the nature of the underlying process (or processes) and the factors that maintain or disrupt continuity.

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APPROVAL SHEET

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The final copies have been examined by the director of the thesis and the signature which appears below verifies the fact that any necessary changes have been incorporated and that the thesis is now given final approval by the Committee with reference to content and form.

The thesis is therefore accepted in partial fulfillment of the requirements for the degree of Master of Arts.

April 20, 1989

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